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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/616,097	07/08/2003	Zhi-Wen Sun	AMAT/8241/CMP/ECP/RKK	1645

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EXAMINER

WONG, EDNA

ART UNIT	PAPER NUMBER
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1753

DATE MAILED: 10/04/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

10/616,097

Applicant(s)

SUN ET AL.

Examiner

Edna Wong

Art Unit

1753

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --
Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 12 September 2005.
- 2a) ☒ This action is **FINAL**. 2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-11, 13-15, 17-28 and 30-36 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1-11, 13-15, 17-28 and 30-36 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- * See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)
Paper No(s)/Mail Date _____
- 4) ☐ Interview Summary (PTO-413)
Paper No(s)/Mail Date. _____
- 5) ☐ Notice of Informal Patent Application (PTO-152)
- 6) ☐ Other: _____

This is in response to the Amendment dated September 12, 2005. The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office action.

Response to Arguments

Claim Objections

Claims **2-4, 6, 14-16, 18, 21, 24 and 27-29** have been objected to because of minor informalities.

The objection of claims 2-4, 6, 14-16, 18, 21, 24 and 27-29 has been withdrawn in view of Applicants' amendment.

Claim Rejections - 35 USC § 112

Claims **21-22, 25 and 32-33** have been rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

The rejection of claims 21-22, 25 and 32-33 has been withdrawn in view of Applicants' amendment.

Claim Rejections - 35 USC § 102

I. Claims **1-7** have been rejected under 35 U.S.C. 102(e) as being anticipated by **Miura et al.** (US Patent Application Publication No. 2003/0155247 A1).

The rejection of claims 1-7 under 35 U.S.C. 102(e) as being anticipated by Miura et al. has been withdrawn in view of Applicants' amendment.

II. Claims **11-19** have been rejected under 35 U.S.C. 102(e) as being anticipated by **Miura et al.** (US Patent Application Publication No. 2003/0155247 A1).

The rejection of claims 11-19 under 35 U.S.C. 102(e) as being anticipated by Miura et al. has been withdrawn in view of Applicants' amendment.

III. Claims **23-30** have been rejected under 35 U.S.C. 102(e) as being anticipated by **Miura et al.** (US Patent Application Publication No. 2003/0155247 A1).

The rejection of claims 23-30 under 35 U.S.C. 102(e) as being anticipated by Miura et al. has been withdrawn in view of Applicants' amendment.

Claim Rejections - 35 USC § 103

I. Claims **8-10** have been rejected under 35 U.S.C. 103(a) as being unpatentable over **Miura et al.** (US Patent Application Publication No. 2003/0155247 A1) as applied to claims 1-7 above, and further in view of **Dubin et al.** (US Patent No. 6,432,821) and **Nagai et al.** (US Patent No. 6,709,563 B2).

The rejection of claims 8-10 under 35 U.S.C. 103(a) as being unpatentable over Miura et al. as applied to claims 1-7 above, and further in view of Dubin et al. and Nagai et al. has been withdrawn in view of Applicants' amendment.

II. Claims **20-22** have been rejected under 35 U.S.C. 103(a) as being unpatentable over **Miura et al.** (US Patent Application Publication No. 2003/0155247 A1) as applied to claims 11-19 above, and further in view of **Dubin et al.** (US Patent No. 6,432,821) and **Nagai et al.** (US Patent No. 6,709,563 B2).

The rejection of claims 20-22 under 35 U.S.C. 103(a) as being unpatentable over Miura et al. as applied to claims 11-19 above, and further in view of Dubin et al. and Nagai et al. has been withdrawn in view of Applicants' amendment.

III. Claims **31-33** have been rejected under 35 U.S.C. 103(a) as being unpatentable over **Miura et al.** (US Patent Application Publication No. 2003/0155247 A1) as applied to claims 23-30 above, and further in view of **Dubin et al.** (US Patent No. 6,432,821) and **Nagai et al.** (US Patent No. 6,709,563 B2).

The rejection of claims 31-33 under 35 U.S.C. 103(a) as being unpatentable over Miura et al. as applied to claims 23-30 above, and further in view of Dubin et al. and Nagai et al. has been withdrawn in view of Applicants' amendment.

Response to Amendment

Claim Rejections - 35 USC § 103

I. Claims **1-7 and 34** are rejected under 35 U.S.C. 103(a) as being unpatentable over **Miura et al.** (US Patent Application Publication No. 2003/0155247 A1) in combination with **Baskaran et al.** (US Patent Application Publication No. 2004/0072419

A1).

Miura teaches a method for depositing a copper seed layer (= reinforces the seed layer and adds thickness to the seed layer within the trenches or via holes) [page 4, [0051]] onto a substrate surface (= a silicon wafer) [page 3, [0046]] containing a barrier layer (page 3, [0049]), comprising:

(a) exposing the substrate surface to a copper solution containing complexed copper ions (page 2, [0019] and [0023]) and having a pH value of less than 7 (= a pH of 4 to 10) [page 3, lines 0040];

(b) applying an electrical bias across the substrate surface (page 4, [0053]); and

(c) reducing the complexed copper ions with the electrical bias to deposit the copper seed layer onto the barrier layer (pages 3-4, [0049] to [0051]).

The barrier layer comprises a material selected from the group consisting of cobalt, ruthenium, nickel, tungsten, tungsten nitride, titanium, titanium nitride and silver (page 3, [0049]).

The copper solution contains a concentration of complexed copper ions within the range from about 0.02 M to about 0.8 M (= 0.05 to 2.0 mol/L) [page 3, [0039]].

The electrical bias generates a current density of less than about 10 mA/cm² across the substrate surface (= 0.1 to 4.0 A/dm²) [page 4, [0053]].

The current density is within the range from about 0.5 mA/cm² to about 3 mA/cm² (= 0.1 to 4.0 A/dm²) [page 4, [0053]].

The copper seed layer has a thickness less than about 200Å (= an average

thickness of 100 to 200 nm) [page 1, [0007]].

The pH value is within a range from about 4.5 to about 6.5 (= a pH of 4 to 10) [page 3, lines 0040]].

The method described by Miura differs from the instant invention because Miura does not disclose the following:

- a. Wherein the complexed copper ions are derived from a copper source selected from the group consisting of copper citrate, copper borate, copper tartrate, copper oxalate, derivatives thereof, and combinations thereof, as recited in claim 1.
- b. Wherein the copper source is copper citrate, as recited in claim 3.

The invention as a whole would have been obvious to one having ordinary skill in the art at the time the invention was made because Miura teaches that the electrolytic copper plating solution of his invention contains copper ions and a complexing agent. The complexing agent includes any material that can form a complex with copper ions such as oxycarboxylic acids and salts thereof (page 2, [0023]). Examples of the oxycarboxylic acid include citric acid (page 2, [0027]).

Complexing the copper ions with citric acid would give copper citrate.

Furthermore, Baskaran teaches plating bath solutions suitable to deposit a copper seed layer or bulk metallization layer (page 6, [0068] to [0072]). Bath solutions deriving copper from sources other than copper sulfate include copper gluconate, sodium copper cyanide, copper sulfamate, copper chloride, copper citrate, copper

fluoroborate and copper pyrophosphate or any combinations thereof (page 6, [0074]).

Useful complexing agents form a stable complex with copper ions and prevent the precipitation of copper hydroxide. Ethylenediaminetetraacetic acid (EDTA),

ethylenediamine (ED), citric acid, and their salts have been found to be particularly suitable copper complexing agents (page 4, [0075]).

II. Claims 8 and 9 are rejected under 35 U.S.C. 103(a) as being unpatentable over **Miura et al.** (US Patent Application Publication No. 2003/0155247 A1) in combination with **Baskaran et al.** (US Patent Application Publication No. 2004/0072419 A1) as applied to claims 1-7 and 34 above, and further in view of **Dubin et al.** (US Patent No. 6,432,821 B1).

Miura and Baskaran are as applied above and incorporated herein.

The method described by Miura and Baskaran differs from the instant invention because they do not disclose the following:

a. Depositing a copper gap-fill layer by exposing the substrate surface to a second copper solution containing free-copper ions; and applying a second electrical bias across the substrate surface to deposit the copper gap-fill layer onto the copper seed layer, as recited in claim 9.

b. Depositing a bulk-fill copper layer by exposing the substrate surface to a third copper solution containing free-copper ions; and applying a third electrical bias across the substrate surface to deposit the copper bulk-fill layer onto the copper gap-fill

layer, as recited in claim 9.

Dubin teaches that a plating program in which an initiation, or seed layer repair, operation is performed by forcing a first forward current, a second forward current is then forced to superfill features less than 0.3 microns in width, and finally, a third forward current is forced to perform a bulk fill operation is a known conventional plating program for filling damascene structures (col. 3, line 66 to col. 4, line 10; and Fig. 2).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the method of Miura by depositing a copper gap-fill by exposing the substrate surface to a second copper solution containing free-copper ions; and applying a second electrical bias across the substrate surface to deposit the copper gap-fill layer onto the copper seed layer; and depositing a bulk-fill copper layer by exposing the substrate surface to a third copper solution containing free-copper ions; and applying a third electrical bias across the substrate surface to deposit the copper bulk-fill layer onto the copper gap-fill layer because Miura teaches that the trenches or via holes may be completely filled with copper using the electrolytic copper plating solution of his invention, or they may be first filled halfway and then applied with a highly acidic or highly basic copper plating solution to be filled completely. The electrolytic copper plating solution of his invention reinforces the seed layer and adds thickness to the seed layer within the trenches or via holes of silicon wafers so that a highly acidic or highly basic copper plating solution, which would otherwise corrode the seed layer, can

be used to plate the silicon wafer (page 4, [0051]).

Modifying the halfway fill to comprise a second forward current (and bias) and the complete fill to comprise a third forward current (and bias) would have eliminated thin seed layer dissolution and would have superfilled the smallest features first and then the largest features in order to provide the desired surface morphology as taught by Dubin (col. 3, line 66 to col. 4, line 10; col. 7, lines 12-38; and Figs. 2 and 7).

Furthermore, it has been shown that the transpositioning of varying steps, or varying the details of a process, as by adding a step or splitting one step into two does not avoid obviousness where the processes are substantially identical or equivalent in terms of function, manner and result. *General Foods Corp. v. Perk Foods Co.* (DC NIII 1968) (157 USPQ 14); *Malignani v. Germania Electric Lamp Co.*, 169 F. 299, 301 (D.N.J. 1909); *Matrix Contrast Corp. v. George Kellar*, 34 F.2d 510, 512, 2 USPQ 400, 402-403 (E.D.N.Y 1929); *Hammerschlag Mfg. Co. v. Bancroft*, 32 F. 585, 589 (N.D.III.1887); *Procter & Gamble Mfg. Co. v. Refining*, 135 F.2d 900, 909, 57 USPQ 505, 513-514 (4th Cir. 1943); *Matherson-Selig Co. v. Carl Gorr Color Gard, Inc.*, 154 USPQ 265, 276 (N.D.III.1967).

As to the copper solutions containing free-copper ions, free-copper ions are inherently present in a highly acidic or highly basic copper plating solution because it is the copper ions that are deposited on the substrate to form the copper seed layer.

III. Claim 10 is rejected under 35 U.S.C. 103(a) as being unpatentable over Miura et

Art Unit: 1753

al. (US Patent Application Publication No. 2003/0155247 A1) in combination with **Baskaran et al.** (US Patent Application Publication No. 2004/0072419 A1) as applied to claims 1-7 and 34 above, and further in view of **Dubin et al.** (US Patent No. 6,432,821 B1) as applied to claims 8 and 9 above, and further in view of **Nagai et al.** (US Patent No. 6,709,563 B2).

Miura, Baskaran and Dubin are as applied above and incorporated herein.

The method described by Miura, Baskaran and Dubin differs from the instant invention because they do not disclose wherein at least one leveling agent is added to the second copper solution to form the third copper solution.

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the method of Miura with wherein at least one leveling agent is added to the second copper solution to form the third copper solution because adding at least one leveling agent to the second copper solution would have retarded the growth of plating at the inlet of a fine recess and made it possible to fully fill the fine recess with copper uniformly without the formation of any void, and further flatten the plating surface as taught by Nagai (col. 17, line 64 to col. 18, line 2).

IV. Claims **11, 13-15, 17-19 and 35** are rejected under 35 U.S.C. 103(a) as being unpatentable over **Miura et al.** (US Patent Application Publication No. 2003/0155247 A1) in combination with **Baskaran et al.** (US Patent Application Publication No. 2004/0072419 A1).

Miura and Baskaran are as applied for the reasons as discussed above and incorporated herein.

V. Claims **20 and 21** are rejected under 35 U.S.C. 103(a) as being unpatentable over **Miura et al.** (US Patent Application Publication No. 2003/0155247 A1) in combination with **Baskaran et al.** (US Patent Application Publication No. 2004/0072419 A1) as applied to claims 11, 13-15, 17-19 and 35 above, and further in view of **Dubin et al.** (US Patent No. 6,432,821 B1).

Miura, Baskaran and Dubin are as applied for the reasons as discussed above and incorporated herein.

VI. Claim **22** is rejected under 35 U.S.C. 103(a) as being unpatentable over **Miura et al.** (US Patent Application Publication No. 2003/0155247 A1) in combination with **Baskaran et al.** (US Patent Application Publication No. 2004/0072419 A1) as applied to claims 11, 13-15, 17-19 and 35 above, and further in view of **Dubin et al.** (US Patent No. 6,432,821 B1) as applied to claims 20 and 21 above, and further in view of **Nagai et al.** (US Patent No. 6,709,563 B2).

Miura, Baskaran, Dubin and Nagai are as applied for the reasons as discussed above and incorporated herein.

VII. Claims **23-28, 30 and 36** are rejected under 35 U.S.C. 103(a) as being

unpatentable over **Miura et al.** (US Patent Application Publication No. 2003/0155247 A1) in combination with **Baskaran et al.** (US Patent Application Publication No. 2004/0072419 A1).

Miura and Baskaran are as applied for the reasons as discussed above and incorporated herein.

VIII. Claims **31 and 32** are rejected under 35 U.S.C. 103(a) as being unpatentable over **Miura et al.** (US Patent Application Publication No. 2003/0155247 A1) in combination with **Baskaran et al.** (US Patent Application Publication No. 2004/0072419 A1) as applied to claims 23-28, 30 and 36 above, and further in view of **Dubin et al.** (US Patent No. 6,432,821 B1).

Miura, Baskaran and Dubin are as applied for the reasons as discussed above and incorporated herein.

IX. Claim **33** is rejected under 35 U.S.C. 103(a) as being unpatentable over **Miura et al.** (US Patent Application Publication No. 2003/0155247 A1) in combination with **Baskaran et al.** (US Patent Application Publication No. 2004/0072419 A1) as applied to claims 23-28, 30 and 36 above, and further in view of **Dubin et al.** (US Patent No. 6,432,821 B1) as applied to claims 31 and 32 above, and further in view of **Nagai et al.** (US Patent No. 6,709,563 B2).

Miura, Baskaran, Dubin and Nagai are as applied for the reasons as discussed

above and incorporated herein.

Applicants state that Dubin describes conducting the deposition process, including sequential reverse current steps, within one solution. Dubin maintains the same chemical components throughout the various steps. In response, the claims 1, 11 and 23, as presently written, are open to using the same copper solution.

Furthermore, the addition of a single copper plating bath additive to chemically differentiate the first, second and/or third copper solutions is not deemed to be an inventive method step because one having ordinary skill in the art has the skill to develop and optimize the first, second and/or third copper solutions for a void-free fill, with the full understanding of the role of the plating solution components (accelerators, levelers, brighteners, wetting agents, and etc.) and their behavior as a function of the copper deposit morphology.

Applicants state that Nagai discloses electrolytic processes for copper that contain basic complexed solutions "with a pH range of 7-14, preferably at a pH of about 9". In response, Nagai is used in the Examiner's rejection only for the teaching of adding a leveling agent to the second copper solution. This would not have destroyed the process disclosed by Muira.

Applicant's amendment necessitated the new ground(s) of rejection presented in

this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Edna Wong whose telephone number is (571) 272-1349. The examiner can normally be reached on Mon-Fri 7:30 am to 4:00 pm.

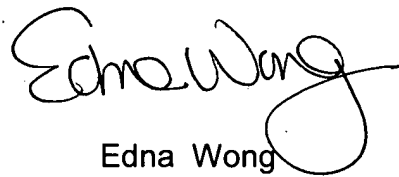
If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nam Nguyen can be reached on (571) 272-1342. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR.

Art Unit: 1753

Status information for unpublished applications is available through Private PAIR only.

For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

A handwritten signature in black ink, appearing to read "Edna Wong". The signature is fluid and cursive, with a large loop at the end of the last name.

Edna Wong
Primary Examiner
Art Unit 1753

EW
September 29, 2005